LUBRICANT COMPOSITIONS FOR PROVIDING ANTI-SHUDDER PERFORMANCE AND ELASTOMERIC COMPONENT COMPATIBILITY

FIELD

The present disclosure relates to lubricant compositions and methods utilizing the lubricant compositions to provide and/or improve anti-shudder capabilities of automotive transmission fluids. The present disclosure also provides lubricant compositions that provide and/or improve compatibility with elastomeric components.

BACKGROUND

New and advanced transmission systems are being developed by the automotive industry. These new systems often involve high energy requirements. Therefore, friction materials technology must be developed to meet the increasing energy requirements of these advanced fluid systems.

The high speeds generated during engagement and disengagement of some of the newer transmission systems mean that a friction system must be able to maintain a relatively constant friction throughout the engagement. It is important that the frictional engagement be relatively constant over a wide range of speeds and temperatures in order to minimize "shuddering" of materials during transmission power shift from one gear to another.

In particular, new high energy type friction materials are being developed and used. The new high energy friction materials are able to withstand high speeds wherein internal transmission plate surface speeds are up to about 65 m/second. It is also important that the friction material be useful under limited lubrication conditions. One such material being developed for automatic transmission applications is a carbon fiber containing material.

In view of new materials and greater demands on transmissions, automotive power transmission fluids are called upon to provide specific frictional properties under very demanding conditions of speed, temperature, and pressure. Changes in a fluid's frictional properties as a function of relative sliding speed, temperature, or pressure may cause performance degradation immediately noticeable to the vehicle operator. Such effects may

include unacceptably long or short gear shifts, vehicle shudder or vibration, noise, and/or harsh shifts ("gear change shock"). Thus, there is a need for transmission fluids that exhibit improved characteristics such as shear and friction stability at high temperatures and pressures. Such fluids would reduce equipment and performance problems while improving the interval between fluid changes. By enabling smooth engagement of torque converter and shifting clutches, these fluids may reduce shudder, vibration, and/or noise, and in some cases improve fuel economy, over a longer fluid lifetime.

Friction modifiers are used in transmission fluids to control friction between surfaces (e.g., the members of a torque converter clutch or a shifting clutch) at low sliding speeds. The result is a friction vs. velocity (u-v) curve that has a positive slope, which in turn leads to smooth clutch engagements and minimizes "stick-slip" behavior (e.g., shudder, noise, and harsh shifts). Many conventional friction modifiers, however, are thermally unstable. Upon prolonged exposure to heat, these additives decompose, and the benefits they confer on clutch performance may be lost.

In addition, deterioration of structural elastomeric elements or components such as seals, belts, gaskets, bushings, filters, and/or hoses in engines, transmissions, gears, and/or axles may occur. Such deterioration may be attributed to interactions between the elastomeric material of said elements and the reactive or deteriorative components of a lubricant composition or fluid. Further, a lubricating fluid should provide appropriate swelling of seals, gaskets, and the like. It is additionally an object of the compositions and methods of the present invention to reduce the deterioration of, improve the compatibility with, and promote proper swell of such seals, hoses, and like elements and components.

SUMMARY OF EMBODIMENTS

In an embodiment, a power transmitting fluid for use in a power transmitting device may comprising a major amount of a base oil and a minor amount of an additive composition. The additive composition may comprise at least one non-dispersant viscosity index improver, wherein the power transmitting fluid provides anti-shudder performance to the power transmitting device.

In another embodiment, a lubricating fluid having compatibility with an elastomeric component may comprise a major amount of a base oil and a minor amount of an additive composition having at least one non-dispersant viscosity index improver.

In another embodiment, a method of improving the anti-shudder capabilities of a power transmission fluid may comprise lubricating a power transmission with a power transmission fluid comprising a major amount of a base oil and a minor amount of an additive composition comprising at least one non-dispersant viscosity index improver.

In another embodiment, a method of improving the torque performance of a power transmission fluid may comprise lubricating a power transmission with a power transmission fluid comprising a major amount of a base oil and a minor amount of an additive composition comprising at least one non-dispersant viscosity index improver.

In another embodiment, a method of improving the compatibility of a lubricating fluid with an elastomeric component may comprise lubricating an elastomeric component with a fluid comprising a major amount of a base oil and a minor amount of an additive composition comprising at least one non-dispersant viscosity index improver.

In another embodiment, a method of promoting seal swell of an elastomeric seal may comprise lubricating the elastomeric seal with a lubricating fluid comprising a major amount of a base oil and a minor amount of an additive composition comprising at least one non-dispersant viscosity index improver.

In another embodiment, a method of making a power transmitting fluid having anti-shudder capabilities may comprise adding to a major amount of a base oil a minor amount of an additive composition having a non-dispersant viscosity index improver.

In another embodiment, a method of making a lubricating fluid having improved compatibility with an elasotmeric component may comprise adding to a major amount of a base oil a minor amount of an additive composition having a non-dispersant viscosity index improver.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates torque performance of a fluid according to an embodiment as measured using a ZF GK test rig.

FIG. 2 illustrates torque performance of a comparative fluid measured using a ZF GK test rig.

DETAILED DESCRIPTION OF EMBODIMENTS

As power transmission fluids operate under increasingly severe conditions, the oils used to lubricate those transmissions should be formulated to endure higher temperatures and pressures. To reduce equipment problems and increase the interval between transmission oil changes, the oil should be formulated so that important oil properties change as little as possible in the face of these stresses. In particular, the shear stability properties of the oil, which depend in great measure on the additive package, should stay relatively constant over a wide range of temperatures and operating speeds. This ensures smooth engagement of torque converter and shifting clutches and minimized shudder, vibration and noise, and improved fuel economy as constant viscosity allows good hydraulic control.

The present disclosure describes compositions and methods that provide and/or improve anti-shudder performance of power transmission fluids, and also methods for providing and/or improving the compatibility of lubricating fluids with elastomeric components, for example, seals, gaskets, belts, and/or hoses. Non-dispersant viscosity index improvers are known to improve rheological properties, such as viscosity index, of power transmission fluids and/or lubricating fluids. Thus, the compositions of the present disclosure provide a single solution to multiple problems, and thus an inherent cost benefit.

In an embodiment, a power transmission fluid may include a base oil and an additive composition. The additive composition may include a non-dispersant viscosity index improver. Non-dispersant viscosity index improvers differ from dispersant viscosity index improvers by the absence of dispersant functional groups. A non-dispersant viscosity index improver suitable for use in at least one of the present embodiments may comprise a polymethacrylate, an olefin copolymer, a polystyrene, a metallocene polymer, a polymer of a hydrogenated diene and/or a copolymer thereof with a vinyl amine, a homopolymer of a hydrogenated conjugated diene or a copolymer thereof with a vinyl aromatic hydrocarbon, and the like. A wide range of molecular weight polymers of the latter type can be utilized as

the base polymer of the non-dispersant viscosity index improver, and such polymers may include linear, branched, or star-shaped configurations.

The presence of a non-dispersant viscosity index improver in the compositions and methods of the present embodiments eliminate and/or reduce the need for conventionally utilized friction-modifying agents or other agents for providing anti-shudder performance. Further, inclusion of a non-dispersant viscosity index improver may improve the anti-shudder properties of a fluid relative to a fluid including a dispersant viscosity index improver. Embodiments may include an amount of a non-dispersant viscosity index improver sufficient to provide and/or improve the anti-shudder characteristics of a power transmission fluid. For example, an additive composition may comprise from about 0.01 wt% to about 50 wt% of non-dispersant viscosity index improver. As a further example, an additive composition may comprise from about 1.0 wt% to about 25 wt% of non-dispersant viscosity index improver. As an even further example, an additive composition may comprise from about 3 wt% to about 15 wt% of non-dispersant viscosity index improver.

In addition, some embodiments provide and/or improve compatibility of elastomeric components found within an automotive transmission, including an automatic and manual transmission, a gear component, and/or an axle component. Such elastomeric components may comprise seals, hoses, gaskets, belts, and the like. Further, these components may be composed of elastomeric materials such as nitrile rubber, polyacrylate, silicone, fluoroelastomers, and/or chlorinated polyethylene. Elastomeric components may deteriorate, shrink, or fail to swell properly because of contact with certain chemicals contained in lubricating fluids. Further, some chemicals, such as seal swell agents, may improve the tolerance of seals and hoses to lubricating fluids. Embodiments disclosed herein have been found to positively interact with seals and hoses to improve tensile strength and/or elongation. Both of these factors are indicative of proper seal swell and resistance or tolerance to deterioration. Such embodiments include a lubricating fluid comprising a non-dispersant viscosity index improver.

The presence of a non-dispersant viscosity index improver in the compositions and methods of the present embodiments eliminate and/or reduce the need for conventionally utilized seal swell agents or other agents. For example, inclusion of a non-dispersant viscosity index improver in a lubricating fluid may improve the compatibility of the

lubricating fluid with elastomeric components. In particular, this improvement may be compared to fluids including dispersant viscosity index improvers and/or fluids including a conventional seal swell agent.

Embodiments may include a suitable amount of a non-dispersant viscosity index improver sufficient to provide the desired swelling and/or provide or improve the compatibility between a lubricating fluid and elastomeric components. For example, an additive composition may comprise from about 0.01 wt% to about 50 wt% of non-dispersant viscosity index improver. As a further example, an additive composition may comprise from about 1.0 wt% to about 25 wt% of non-dispersant viscosity index improver. As an even further example, an additive composition may comprise from about 3 wt% to about 15 wt% of non-dispersant viscosity index improver.

Base Oil

Base oils suitable for use in formulating transmission fluid compositions may be selected from any of the synthetic or natural oils or mixtures thereof. Natural oils include animal oils and vegetable oils (e.g., castor oil, lard oil) as well as mineral lubricating oils such as liquid petroleum oils and solvent treated or acid-treated mineral lubricating oils of the paraffinic, naphthenic or mixed paraffinic-naphthenic types. Oils derived from coal or shale are also suitable. The base oil typically has a viscosity of about 2 to about 15 cSt or, as a further example, about 2 to about 10 cSt at 100° C. Further, gas-to-liquid stocks are also suitable.

The synthetic base oils include alkyl esters of dicarboxylic acids, polyglycols, and alcohols, poly-alpha-olefins, including polybutenes, alkyl benzenes, organic esters of phosphoric acids, and polysilicone oils. Synthetic oils include hydrocarbon oils such as polymerized and interpolymerized olefins (e.g., polybutylenes, polypropylenes, propylene isobutylene copolymers, etc.); poly(1-hexenes), poly-(1-octenes), poly(1-decenes), etc. and mixtures thereof; alkylbenzenes (e.g., dodecylbenzenes, tetradecylbenzenes, di-nonylbenzenes, di-(2-ethylhexyl)benzenes, etc.); polyphenyls (e.g., biphenyls, terphenyl, alkylated polyphenyls, etc.); alkylated diphenyl ethers and alkylated diphenyl sulfides and the derivatives, analogs and homologs thereof and the like.

Alkylene oxide polymers and interpolymers and derivatives thereof where the terminal hydroxyl groups have been modified by esterification, etherification, etc., constitute another class of known synthetic oils that may be used. Such oils are exemplified by the oils prepared through polymerization of ethylene oxide or propylene oxide, the alkyl and aryl ethers of these polyoxyalkylene polymers (e.g., methyl-polyisopropylene glycol ether having an average molecular weight of about 1000, diphenyl ether of polyethylene glycol having a molecular weight of about 500-1000, diethyl ether of polypropylene glycol having a molecular weight of about 1000-1500, etc.) or mono- and polycarboxylic esters thereof, for example, the acetic acid esters, mixed C_{3-8} fatty acid esters, or the C_{13} Oxo acid diester of tetraethylene glycol.

Another class of synthetic oils that may be used includes the esters of dicarboxylic acids (e.g., phthalic acid, succinic acid, alkyl succinic acids, alkenyl succinic acids, maleic acid, azelaic acid, suberic acid, sebacic acid, fumaric acid, adipic acid, linoleic acid dimer, malonic acid, alkyl malonic acids, alkenyl malonic acids, etc.) with a variety of alcohols (e.g., butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-ethylhexyl alcohol, ethylene glycol, diethylene glycol monoether, propylene glycol, etc.) Specific examples of these esters include dibutyl adipate, di(2-ethylhexyl)sebacate, di-n-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azelate, dioctyl phthalate, didecyl phthalate, dieicosyl sebacate, the 2-ethylhexyl diester of linoleic acid dimer, the complex ester formed by reacting one mole of sebacic acid with two moles of tetraethylene glycol and two moles of 2-ethylhexanoic acid and the like.

Esters useful as synthetic oils also include those made from C_5 to C_{12} monocarboxylic acids and polyols and polyol ethers such as neopentyl glycol, trimethylol propane, pentaerythritol, dipentaerythritol, tripentaerythritol, etc.

Hence, the base oil used which may be used to make the transmission fluid compositions as described herein may be selected from any of the base oils in Groups I-V as specified in the American Petroleum Institute (API) Base Oil Interchangeability Guidelines. Such base oil groups are as follows:

Base Oil Group[1]	Sulfur (wt%)		Saturates (wt%)	Viscosity Index

Group I	> 0.03	and/or	< 90	80 to 120
Group II	≤ 0.03	And	≥ 90	80 to 120
Group III	≤ 0.03	And	≥ 90	≥ 120
Group IV	all polyalphaolefins (PAOs)			
Group V	all others not included in Groups I-IV			

[1]Groups I-III are mineral oil base stocks.

As set forth above, the base oil may be a poly-alpha-olefin (PAO). Typically, the poly-alpha-olefins are derived from monomers having from about 4 to about 30, or from about 4 to about 20, or from about 6 to about 16 carbon atoms. Examples of useful PAOs include those derived from octene, decene, mixtures thereof, and the like. PAOs may have a viscosity of from about 2 to about 15, or from about 3 to about 12, or from about 4 to about 8 cSt at 100° C. Examples of PAOs include 4 cSt at 100° C poly-alpha-olefins, 6 cSt at 100° C poly-alpha-olefins, and mixtures thereof. Mixtures of mineral oil with the foregoing poly-alpha-olefins may be used.

The base oil may be an oil derived from Fischer-Tropsch synthesized hydrocarbons. Fischer-Tropsch synthesized hydrocarbons are made from synthesis gas containing H_2 and CO using a Fischer-Tropsch catalyst. Such hydrocarbons typically require further processing in order to be useful as the base oil. For example, the hydrocarbons may be hydroisomerized using processes disclosed in U.S. Pat. Nos. 6,103,099 or 6,180,575; hydrocracked and hydroisomerized using processes disclosed in U.S. Pat. Nos. 4,943,672 or 6,096,940; dewaxed using processes disclosed in U.S. Pat. No. 5,882,505; or hydroisomerized and dewaxed using processes disclosed in U.S. Pat. Nos. 6,013,171; 6,080,301; or 6,165,949.

Unrefined, refined and rerefined oils, either natural or synthetic (as well as mixtures of two or more of any of these) of the type disclosed hereinabove can be used in the base oils. Unrefined oils are those obtained directly from a natural or synthetic source without further purification treatment. For example, a shale oil obtained directly from retorting operations, a petroleum oil obtained directly from primary distillation or ester oil obtained directly from an esterification process and used without further treatment would be an unrefined oil. Refined oils are similar to the unrefined oils except they have been further treated in one or more purification steps to improve one or more properties. Many such purification techniques are

known to those skilled in the art such as solvent extraction, secondary distillation, acid or base extraction, filtration, percolation, etc. Rerefined oils are obtained by processes similar to those used to obtain refined oils applied to refined oils which have been already used in service. Such rerefined oils are also known as reclaimed or reprocessed oils and often are additionally processed by techniques directed to removal of spent additives, contaminants, and oil breakdown products.

The base oil may be combined with an additive composition as disclosed in embodiments herein to provide a power transmission fluid. The base oil may be present in the power transmission fluid in an amount from about 50 wt% to about 95 wt %.

Other Optional Components

The power transmission fluid may also include conventional additives of the type used in automatic transmission fluid formulations in addition to the components described above. Such additives include, but are not limited to, ashless dispersants, friction modifiers, antioxidants, extreme pressure additives, corrosion inhibitors, antiwear additives, antirust additives, metal deactivators, antifoamants, pour point depressants, air entrainment additives, metallic detergents, and/or additional seal swell agents.

Additives used in formulating the compositions described herein can be blended into the base oil individually or in various sub-combinations. However, it is suitable to blend all of the components concurrently using an additive concentrate (i.e., additives plus a diluent, such as a hydrocarbon solvent). The use of an additive concentrate takes advantage of the mutual compatibility afforded by the combination of ingredients when in the form of an additive concentrate simulates actual plant blending conditions. Also, the use of a concentrate reduces blending time and lessens the possibility of blending errors.

The power transmission fluids disclosed herein may include fluids suitable for any power transmitting application, such as a step automatic transmission, having from about 3 to about 7 speeds, or a manual transmission. Further, the power transmission fluids of the present disclosure are suitable for use in transmissions with a slipping torque converter, a lock-up torque converter, a starting clutch, and/or one or more shifting clutches. Such transmissions include three-, four-, five-, six-, and seven-speed transmissions, and

continuously variable transmissions (chain, belt, or disk type). They may also be used in manual transmissions, including automated manual and dual-clutch transmissions.

EXAMPLES

Fluids tested in the following examples included the following components prepared in the proportions disclosed below. Components that were varied are discussed with respect to each example below. Unless otherwise specified tested samples were identical except for varied components.

Component type	**Example 2 Proportion in Finished Fluid, wt%**	**Example 2 Proportion in Finished Fluid, wt%**
Antioxidants	0.1 – 2.5	0.2 - 0.5
Rust Inhibitors	0 – 0.2	0 - 0.06
Thiadiazole	0 – 2.0	0.01 - 0.6
Antifoam agents	0 – 1.5	0.05 - 0.20
Friction Modifiers	0 - 5.0	0.005 - 0.25
Dispersant	0 – 10	1 - 5%
Seal Swell Agents	0 – 20	0 -10
Polymethacrylate viscosity index improver	0.5 – 30	3 – 25
Basestock	60 – 90	60 – 90
Diluent Oil	0 – 20	2 – 5

EXAMPLE 1

Two transmission fluid formulations were tested and evaluated for effectiveness in reducing shudder. Each fluid had identical concentrations of supplemental additives and differed only in the types of viscosity index improver.

A polymethacrylate non-dispersant viscosity index improver was used in Formula A at a concentration of 5.13 wt%, and a viscosity index improver with dispersant functionality was used in Formula B at a concentration of 5.13 wt%.

As shown in Figures 1 and 2, the two automatic transmission fluids were subjected to shudder testing by evaluating friction characteristics using the ZF GK rig. This test was developed by ZF to measure a slip-controlled clutch's opening and closing performance. An interchangeable intermediate shaft allows the measurement of frictional vibration that is the basis for evaluation of "green" or initial shudder characteristics of the test fluid. The Green Shudder portion of the "GVRK-Kurztest CFT23" consists of a torque controlled continuous slip module, containing three 20-minute sections. The entire sequence encompasses 60 minutes of test time. During each 20-minute section, force is proportional to both slip speed and output torque. The result is a 0.345 m/s (50.0 rpm) constant clutch speed, with variable force to control 100Nm of output torque, which is also constant. Each 20-minute section is analyzed for torque variation. Due to the 1000 Hz speed data acquisition, shudder can be depicted. A 1-minute stabilization period takes place between each continuous slip section. Test fluid temperature is controlled at 120°C.

Measurements in Figures 1 and 2 are displayed as torque over the function of time. The variation in torque measurements is indicative of shudder. Fluids without shudder will display constant torque over time. Fluids with shudder will display varying torque over time.

Shudder tests were run with a polymethacrylate non-dispersant viscosity index improver fluid (Formula A) in Figure 1 and a dispersant viscosity index improver (Formula B) in Figure 2. The green shudder characteristics of Formula A in Figure 1 show a reduction in green shudder associated with the incorporation of a non-dispersant viscosity index improver. The results using Formula A demonstrate no green shudder, as evidenced by constant torque over time. The results using Formula B demonstrate varying torque over time which is indicative of green shudder.

EXAMPLE 2

The incorporation of a non-dispersant viscosity index improver in a lubricating fluid was tested for compatibility by representative elastomeric component. The component tested

was a hose composed of a chlorinated polyethylene. Table 1 demonstrates the results obtained from the testing of several power transmission fluid with the chlorinated polyethylene hose. The performance was determined by the tensile strength and the elongation of the hose at the end of the test, with a more positive number indicating better performance. Sample 1 did not contain any of non-dispersant viscosity index improver, dispersant viscosity index improver, or seal swell agent. Sample 2 contained an equal amount of a non-dispersant viscosity index improver and a dispersant viscosity index improver. Sample 3 contained an equal amount of a non-dispersant viscosity index improver and a dispersant viscosity index improver and additionally a seal swell agent. Sample 4 contained a non-dispersant viscosity index improver and a seal swell agent. All other components in the fluids tested were identical.

Table 1.

	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**
Non-dispersant viscosity index improver, wt%	0.00	5.80	5.80	10.80
Dispersant viscosity index improver, wt%	0.00	5.80	5.80	0.00
Seal Swell Agent, wt%	0.00	0.00	0.40	0.60
Tensile Strength, %	-55.07	-52.22	-51.89	-41.89
Elongation, %	-74	-77.74	-73.19	-68.48

The results shown in Table 1 show that Sample 4, which contained non-dispersant viscosity index improver, demonstrated superior tensile strength compared to samples having less or no non-dispersant viscosity index improver. Furthermore, the incorporation of a seal swell agent to Samples 3 and 4 did not provide a significant benefit. Notably, the benefit

achieved through the use of solely the non-dispersant viscosity index improver greatly exceeded that achieved by the mixed formulation with or without the seal swell agent.

At numerous places throughout this specification, reference has been made to a number of U.S. Patents. All such cited documents are expressly incorporated in full into this disclosure as if fully set forth herein.

Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. As used throughout the specification and claims, "a" and/or "an" may refer to one or more than one. Unless otherwise indicated, all numbers expressing quantities of ingredients, properties such as molecular weight, percent, ratio, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the specification and claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.